ADVANCED REACTOR SAFEGUARDS & SECURITY

Managing Emerging Technologies

ARSS Spring Program Review

PRESENTED BY

Christopher Spirito (INL)

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Background and Context

As the nuclear industry begins to integrate novel technologies such as Cloud Computing, Artificial Intelligence, Digital Twins, Quantum Computing, and others, there is a critical need for comprehensive, informed guidance on their impacts on communication security, network, and system architectures, and new security proposals like Zero Trust Architectures.

The drive behind this R&D is to assist Advanced Reactor, Regulator, and Cyber Defense Stakeholders in comprehending how these emerging technologies will affect their design, construction, and operational decisions, thereby enhancing decision-making through an understanding of uncertainties and risks related to these technologies.

How we bounded what is an Emerging Technology

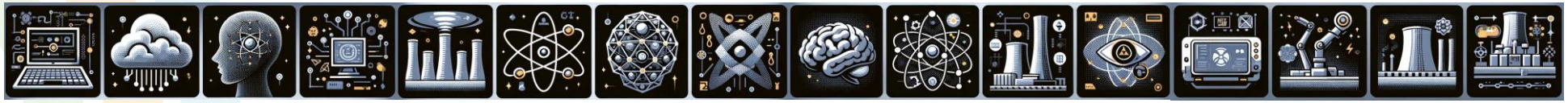
The following criteria were used to bound ”emerging technology":

- **Relevance**: The technology should be applicable to advanced nuclear reactors and contribute to enhancing their performance, safety, or security. This ensures that the technology is relevant to the context provided.
- **Emerging or underutilized**: The technology should either be relatively new or not yet widely implemented in the nuclear industry. This could include cutting-edge technologies, as well as established technologies that have not yet been extensively applied within the context of nuclear reactor instrumentation and control architectures.
- **Potential for significant impact**: The technology should have the potential to make a substantial difference in the way advanced nuclear reactors are designed, built, operated, or maintained. This ensures that the technology has the potential to address key research and development needs in the nuclear industry.
- **Adaptability**: The technology should be adaptable to the unique requirements of advanced nuclear reactors, considering factors such as extreme operating conditions, radiation exposure, and stringent safety and security standards.

Emerging Technologies we considered

The following emerging technologies were considered:

- **Cloud Computing:**
  Leveraging remote computing resources for data storage and processing, enabling real-time monitoring and analysis of reactor systems.
- **Artificial Intelligence (AI) and Machine Learning (ML)**
  Advanced algorithms for predictive maintenance, anomaly detection, and optimizing reactor operations.
- **Digital Twins:**
  Virtual models of reactors simulating real-time operations, allowing for advanced diagnostics, predictive maintenance, and scenario analysis.
- **Quantum Computing:**
  Enhancing communication security and information protection, providing advanced computational capabilities for reactor simulations and optimization.
- **Advanced Robotics:**
  Utilizing autonomous and semi-autonomous robots for inspection, maintenance, and emergency response in hazardous environments.
- **Advanced Sensors and IoT:**
  Integrated sensor networks for real-time data collection, monitoring, and analysis of reactor systems.
- **Augmented and Virtual Reality (AR/VR):**
  Enhanced training and simulation environments for reactor operators and maintenance personnel.
- **Blockchain Technology:**
  Secure, decentralized data storage and tracking for enhanced cybersecurity and supply chain management.
- **Additive Manufacturing (3D Printing):**
  Rapid prototyping and production of reactor components, reducing lead times and costs.
- **Advanced Materials:**
  Innovative materials and coatings for increased reactor performance, safety, and longevity.



Emerging Technologies Lifecycle Map

Emergent Technology	Reactor Design	Construction	Operations	Maintenance and Decommissioning	Challenges	Vendors
Quantum Resistant Cryptography (Data Integrity)	Secure Communication and Data Sharing	Supply Chain Security	Real-Time Data Encryption, Remote Access and Control, IR		Post-Quantum Crypto, Homomorphic Encryption, ZK Proofs, QKD, S-MPC	Entrust SandboxAQ Thales
Hardware Root of Trust (Device Integrity and Security)	Integration of Secure Components, Reliability and Safety Modeling	Secure Supply Chain Management, Component Verification	Operational Security and Efficiency, IR	Maintenance and Firmware Updates, Lifecycle Management	Investment $$, Regulatory Compliance, Tech. Complexity	Vendor TPMs, Siemens SCALANCE, Honeywell PKS
Secure Tokens (Secure Auth & Access to Systems and Data)	Access Control to Design Documents, Collaboration Platforms	Physical Access Control, Network Security, Equip Material Management	Physical Security, Data Access and Mgmt., Vendor Access, ER/IM	Maintenance Access Control, Data Security	Environmental Resilience, Enhanced Security Protocols, Interop	Gemalto, HID Global, Yubico, Enrust, RSA
Artificial Intelligence (Enhancing Efficiency and Security)	Simulation and Modeling, Optimization of Design	Project Management, Quality Assurance	Predictive Maintenance, Optimization, Anomaly Detection and Response		Integration and Training, Integration Complexity, Reliance on Data	Atomic Canyon, General Atomics, Microsoft
Blockchain Technology (System for Recording Transactions)	Intellectual Property Protection, Collaboration Tools	Supply Chain Management, Contract Management	Regulatory Compliance, Maintenance Scheduling, IR	Asset Disposal	Regulatory Compliance, Legacy Integration, Scalability, Human Factors	IBM Blockchain, Hyperledger, R3, Consensys
Virtual Reality (Enhance Safety, Efficiency, and Training)	Enhanced Visualization and Prototyping, Training	Streamlined Workflow and Coordination, Remote Collaboration	Operational, Maintenance, and Security Training + Sims		Investment $$, Technical Compatibility, Usability , Regulatory Compliance	X-Energy, GE Hitachi Nuclear Energy, Fortum

Emerging Technologies Architecture Map

Research Area						
Secure Communication Protocols	Protocol Efficiency and Scalability	RT Data Integrity and Confidentiality	Authentication and Access Control	Post-Quantum Cryptography	Secure Firmware and Hardware Comms	Test and Validation Frameworks
Human Factors and Insider Threats	Behavioral Analytics and Anomaly Detect		RBAC and Least Privilege	Insider Threat Detection Systems	Forensic Analysis and Incident Response	Simulation and Training Scenarios
Supply Chain Security	Risk Assessment Models		Cyber Passport	Counterfeit Detection		
Cyber-Physical Systems	RT Monitoring and Anomaly Detection		Interdependencies and Cascading Effects		Testing and Validation (Research)	AI and Machine Learning
Cyber Security	Intrusion Detection and Prevention		Zero Trust Architecture			
SD Perimeter	Architecture Customization		Identity and Access Management		Continuous A&A	Latency Analysis
Anomaly Detection	Real-Time Processing and Response		Integration with Existing Security Infrastructure		Reduction of False Positives and Negatives	
SIEM	Data Integration and Correlation		Advanced Threat Detection using AIML		IR Automation	Compliance Monitoring
Robotic Process Automation	Secure RPA Deployment		Anomaly Detection in RPA Operations		Compliance and Auditability	Ethical And Privacy Concerns
Smart Cards	Enhanced Security Features		Biometric Integration	IoT and Smart Devices	IR and Recovery	

M2 Publication Components

Stochastic Models with Use Cases to Inform Application
We will provide a guide on how to implement stochastic models for emerging technology analysis, with examples such as predictive maintenance forecasting and operational safety assessments.

Resiliency and Adaptability Considerations
We will provide a guide on how to enhance resiliency and adaptability in nuclear systems utilizing emerging technologies, with examples such as adaptive safety protocols and flexible response strategies to environmental changes.

Threat Intelligence
We will provide a series of emerging technology threat intelligence briefings with examples such as cross-sector threat mapping and incident response simulations.

Training Workshops and Awareness Seminars
We will provide a series of workshops and awareness seminars on managing the impact of emerging technologies.

Community Maps to Support Collaboration and Information Sharing
We will provide a series of community maps for better collaboration and information sharing among nuclear industry stakeholders on management of emerging technologies.